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4 Selecting a Restoration Approach

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4.2 General Approaches to Restoring Habitat

(6-8 pages for following sections 4.2.1 to 4.2.4 in total)

Riparian and aquatic habitats are the combined expression of physical, chemical, and biological attributes of the environment resulting from numerous processes operating throughout a watershed (Spence et.al 1996). These processes are dynamic in nature and operate at multiple spatial and temporal scales. In fluvial ecosystems, this spatial and temporal environmental heterogeneity can be associates with characteristic levels of ecological organization (Poff and Ward 1990). The essence of a fluvial ecosystem is the dynamic equilibrium of the physical system, which in turn establishes a dynamic equilibrium in the biological components (NRC 1992). Vannote et.al (1980) suggest that in fluvial environments, the entire system be viewed as a continuously integrating series of physical gradients and biotic adjustments. While complex, species have evolved and adapted life history strategies that allow them to persist in this diverse environment of constant change and disturbance.

The processes that shape and create habitat act as a form of natural disturbance to the system (Spence et.al 1980). Disturbance can come in the form of a rare catastrophic event such as a volcanic eruption or in a more predictable pattern such as the input of fine sediment from a clearcut forest. Disturbance may be from daily or seasonal events to events that happen on a geologic time scale. Spatially, disturbance may operate on a local scale, impacting an individual pool, or on a basin scale. Habitat diversity and complexity results from interactions between natural disturbance events. Regular disturbance means that habitat is dynamic. As such, disturbance mechanisms and their recurrence intervals must be considered when evaluating how processes will interact on a particular restoration project, recognizing that the type and periodicity of disturbance varies by watershed. The goal of fluvial restoration should be to restore the river or stream to dynamic equilibrium (NRC 1992).

Incorporating a process-based mindset is essential to successful “restoration”. Furthermore, this mindset needs to be applied on the watershed level to be most effective over the long term.

Unfortunately, most process based restoration projects are site-specific. These projects need to be reviewed in a watershed context before implementation. For instance, projects that strive to achieve a particular habitat target or desired quantity / quality of a particular habitat type (such as a mitigation project), may not be realistic. Targets need to be flexible in time and space in response to the action of watershed processes. In those cases, the required mitigation target may determine the selection of a general approach to habitat creation. It is essential to have a vision of how the individual site-specific action fits into the larger context of watershed restoration and recovery of fish species.

In this section, we describe three general approaches to creating habitat. These include:

- Direct creation of habitat,
- Process-derived habitat development, and
- Managed inputs of material to a system.

Each of these approaches is worthwhile provided they are applied appropriately and that the expectations are understood. These approaches are not mutually exclusive. More than one may be necessary to ensure that short and long-term project objectives are met. All approaches need to address the source of the problem in order to provide long-term habitat benefits. When evaluating or planning restoration / recovery actions, a watershed assessment is recommended. Once complete, project proponents are advised to adopt an approach that follows this prioritization (Roni et.al 2002):

1. Protection of areas with intact processes and high-quality habitat (strongholds, refugia and key sub-watersheds);
2. Connectivity and access to habitat (reconnection of isolated high-quality fish habitat such as instream or off-channel habitat made inaccessible by culverts or other man-made obstructions);
3. Process-based restoration including land use recovery or watershed restoration (restoration of sediment dynamics, large wood dynamics, hydrology, adequately sized healthy riparian zone, floodplain processes, channel evolutionary processes);
4. Instream habitat enhancement (Structure-based restoration, within limits of sound design philosophy, which emphasizes: self sustaining structures; low risk of structures destablizing the channel, becoming unstable themselves, or causing export of valuable riparian or aquatic resources (wood, soils, shade, gravel); high probability of success; commitment to maintain structures during intended lifetime; structures done in concert with restoration of processes which will take over when structures are gone; purpose of structures is habitat restoration rather than infrastructure protection, bank stabilization, flood control, etc; structures that do not inhibit channel processes; structures designed to mesh with geomorphic processes and riparian ecological function.

4.2.1 Direct Creation of Specific Habitats

As the name implies, direct creation of specific habitats involves actively constructing a habitat to address a perceived problem or deficiency in the system. For instance, it may involve constructing a salmonid spawning pad, excavating pools, adding cover, or constructing a side channel. The focus behind the direct creation of specific habitats is to achieve a desired fisheries benefit at the time of completion of the project. This approach has the benefit of producing almost immediate habitat value. However, there is a tendency in this restoration approach to over-emphasize habitat for a specific target species and not give full consideration to the processes involved in creating and maintaining the habitat, or to the habitat needs of other fish and wildlife species. Direct creation of specific habitats may be an acceptable mitigation approach with a target of restoration or replacement of specific pre-project habitat conditions. It may also be an acceptable stream habitat enhancement or creation approach. However, without consideration of processes, this approach is prone to failure or, at most, to providing short-term benefits to a target species.

Placeholder for 90%: Provide example of success and failure of this approach when process is and is not accounted for, respectively.

As previously stated, the process of habitat creation, evolution, and destruction in a natural system is spatially and temporally dynamic. As such, the quantity, quality, and distribution of specific habitats are constantly changing. Creation of certain "rigid, fixed" habitat types such as pools behind notched log weirs is less common in modern restoration than in the past. Experience has demonstrated that rigid constructed habitats are often short-lived and less sustainable than "process based" or "land-use based" recovery actions. Rigid habitats have a limited ability to adjust and adapt to dynamic stream conditions. For example, the value of a "rigid" structure placed in the stream to immediately create summer pool habitat may be lost under the first high flow. Because it is not self-sustaining, habitat created by direct means may require high maintenance and/or repeat application in order to provide long-term benefits to the system. As a result, direct creation of habitat as a stand-alone approach is often a less effective use of limited funds when compared to a process-based approach in the long-term.

Experience has demonstrated that the direct creation of specific habitats is most acceptable when the future evolution of the physical condition is factored into the project design and implementation. As with any restoration approach, a dynamic project that integrates process more closely mimics the natural condition and is more likely to be successful, in terms of effectiveness and longevity, than a static project that does not. As such, developing and defining realistic goals and objectives is essential. Both short term and long term expectations must be addressed. Short term, post construction gains in habitat quantity may be lost within a few years resulting in minimal overall habitat and species benefits. However, in some situations it may be acceptable and appropriate to conduct a project that provides a short-term solution in combination with another approach that satisfies a long-term objective.

Certain types of projects (techniques) are examples of direct creation of habitat. The creation and/or restoration of flow to side channel habitats is a good example of an acceptable technique for providing rearing habitat. With this technique, the benefits can be immediate, however the sustainability of the habitat must be assessed both hydrologically and geomorphically. Simply introducing flow into a side channel does not ensure long-term project success. Debris jams are another means of directly providing habitat. The intent with this technique is to immediately provide structural complexity and hydraulic diversity. These physical features are favorable as juvenile rearing and holding habitat. Debris jams are often engineered to remain rigid and withstand a particular design flow. The intentional rigid design of debris jams provides a unique environment for natural processes to act upon. Debris jams integrate process-promoting scour and deposition while providing a medium continued and enhanced structural complexity. These two examples illustrate the variation in scale associated with this type of approach.

Placeholder for 90% - Describe situations when this approach most applies, i.e., relatively stable systems with relatively stable watersheds (not aggressively urbanizing or being logged, not characterized by lots of landslides, aggrading, degrading, not isolated from its floodplain, etc).

4.2.2 Process-Derived Habitat Development

True restoration must take into account the dynamic nature of streams and rivers by allowing enough spatial and temporal scope for natural processes, including floods, to occur (NRC 1992). Development and enhancement of habitat through restoration of natural channel process is the pro-active approach to long-term sustainable restoration (Roni et.al 2002). This approach encourages the creation and maintenance of habitat through natural disturbance processes and fluvial function.

Restoration of natural process may be accomplished in a passive manner, where processes are allowed to recover naturally over time, aided by changes in or restrictions of riparian and watershed land use that originally limited natural process. The development of habitat through the process-derived approach also includes zones, reducing sediment input through man-made sources such as agriculture and deforestation that give the stream a chance to heal itself. Alternatively, process-based habitat restoration may be accomplished in a more pro-active manner where process is encouraged through the installation of structures or manipulations of the channel that promote natural processes.

The scale of process is dynamic in space and time. The physical and chemical characteristics of streams and rivers are the manifestation of processes operating at many spatial and temporal scales (Spence et.al 1996). In space, processes may operate synergistically at the site, reach, or watershed scales in a simultaneous manner. For example, stream hydrology (watershed scale) affects cottonwood forest establishment via flooding and water availability, which in turns affects point bar/seed bed establishment (reach scale), which affects stream geomorphology through local scour, resistance to shear, erosion, wasting (reach and site scale).

In other instances, natural processes may operate independently on a localized / site basis, through a specific structural element which encourages scour or deposition, or on a larger scale / reach basis through gravel recruitment from a natural disturbance such as mass wasting, and/or on a watershed scale through a flood resulting in channel migration or erosion.

How process shapes habitat is often complex and often unpredictable. Our frame of reference is often limited. For instance, we may not have seen the river and observed processes at play under a particular flow event such as a flood with a 50-year recurrence interval. Similarly, we may not fully appreciate how significantly runoff patterns have changed with urbanization. If left on its own, a stream will eventually adjust to new conditions (supply of water, sediment, wood, and nutrients) and eventually reach equilibrium provided it is not subject to additional impact. Achieving equilibrium could take years, decades, centuries depending on extent and nature of changes in watershed. In situations where natural processes are not functioning to shape the system as "desired" or when the "desired" timeframe is more immediate, an approach that encourages process may be appropriate. A sound justification with a clear understanding of the intended goals and objectives of the project is essential. In certain situations, it may be that emergency measures are justified to rapidly encourage process and achieve project goals.

This approach may or may not provide immediate habitat benefits but should provide long-term benefits. If designed correctly, this approach is low-maintenance and self-sustaining. This approach can be used in combination with direct habitat creation to provide immediate benefits as well as long-term.

There are several types of applications of this approach. On the site level, for example, structural elements (boulders, large woody debris) may be placed in the channel to stimulate scour processes to provide pool habitat and spawning gravel sorting. Similarly, on the reach level, regulated river operations may be altered to provide flows that mobilize the streambed and flush fine sediments from spawning gravels. In both instances, fluvial and geomorphic processes function to create desired habitat. However, short term and long term expectations may differ considerably with each type of application. Woody debris may function for several years initially and then deteriorate or be dislodged. Gravel flushing may be effective in the short term and lose its effectiveness over time.

Placeholder for 90% Examples –
Site level – lwd, jams – create the structure that collects the jam material, scour structures
Reach level - regulated river operations – which could constrain reestablishing riparian forest

4.2.3 Manage Inputs of Material to a Channel

The supply, transport, and delivery of sediment, nutrients, and organic debris within a stream system are essential to ecosystem health. Sediment transported from upland areas into stream channels determines the nature and quality of salmonid habitat in streams, rivers, and estuaries, and can greatly influence channel form and process. Sediment supply is most commonly reduced as a result of impoundments and dams in the channel that prevent transport. The development and persistence of morphological structures used for spawning, incubation, and rearing depend on the rate at which sediment is delivered and the composition of deposited materials.

Placeholder for 90%: Add paragraph similar to previous about nutrients and organic debris for 90%. Include description of what each is, why important, how it is commonly limited, and what impacts the limited supply have.

In situations where the natural supply of sediment, nutrients, or organic debris has been reduced or compromised, it may be necessary to supplement the natural supply. For the purpose of this manual, supplementation is defined as the input of materials, including gravel, carcasses, and wood, into a channel without specialized placement. The goals and objectives of supplementation are to artificially stimulate the supply to the stream system.

The use of this approach requires an understanding of the processes involved in transport and movement of materials through the system. Effective supplementation relies on channel flow for material delivery and distribution. As such, this technique may be most appropriate in situations where stream processes have not been altered to the point of impacting material transport and delivery. This approach usually will not provide immediate benefits to stream habitat. It may take weeks, months, or years before benefits are realized, depending on the magnitude and timing of flows experienced in the channel. As hydrology is difficult to predict, the timing, extent, and longevity of material distribution is also difficult to predict. There is also a risk of desired results never being realized, and of potential undesirable consequences if the material gets deposited where it compromises infrastructure.

Placeholder for 90% : Provide an example

Supplementation is justified when natural supply sources have been exhausted or when existing channel processes limit the availability or distribution of inputs. This technique is most suitable when applied at the site or reach scale as the scope of implementation will most likely be too vast at the watershed scale. Supplementation is not typically a “one time only” technique. It will need to be periodically repeated for as long as the natural supply and delivery of material to the system is constrained. In some instances, supplementation may require a substantial commitment of resources to achieve the desired result in both the short- and long-term.

Supplementing inputs to the channel may be a useful approach when other restoration of natural process and input sources require considerable time to become established. For example, restoration natural inputs of large wood to a channel may be accomplished through restoration of a riparian zone. The restored riparian zone will eventually provide a source of large woody material to the system, though supplementation may be necessary until the riparian zone has become fully established, which may take decades. Supplementation should be suspended when the natural supply processes have recovered. There may be instances in which processes will likely never be restored (e.g., a permanent dam that blocks downstream gravel movement). In such cases, a long-term commitment to periodic material supplementation will be needed to sustain habitat.

4.2.4 Replication of Natural Conditions

Replication of natural conditions refers to the creation of channel and habitat forms and features based on natural reference conditions. Replicating natural conditions is not a stand-alone restoration approach, but rather is one way of achieving each of the three general approaches described above. It requires a thorough understanding of natural process because many of the evident structural and bio-diversity attributes that we observe and measure in a reference reach or upland site are products of disturbance and ecological response processes.

Replicated natural conditions may provide immediate habitat value, but their longevity will require careful consideration of the processes that result in these forms in nature. As such, results can be good or disastrous depending on whether or not the copied natural condition was appropriate for the site and applied correctly. If the process that promotes and maintains the natural condition form is not accounted for in design and implementation and the finished project simply mimics natural habitat form, there is a high probability of failure. Conversely, when the project integrates process and the replicated condition is a close replication of natural conditions, the project is likely to be a success.

Replication can simulate conditions as though natural processes have been at work. Rather than creating “rough” conditions for process to act upon, replication creates a refined approximation of the desired conditions with subtle adjustment occurring via fluvial and geomorphic process. Replication allows for integration with natural processes including channel migration, bank deformability, erosion, and mobility of structural elements.

Application of this approach requires a reference stream or reach for comparison. For effective replication, the reference reach must have conditions present that reflect the physical, hydraulic, hydrologic, and geomorphic processes operating in the subject reach. Replication requires measurement of these attributes with consideration to both spatial and temporal scales. The accuracy of replication depends on an appropriate reference and reliable measures of habitat conditions and processes. The assumption is that the reference reach is in a state of equilibrium with watershed inputs. One must determine if the reference reach is really a reference reach or is it a novel assemblage of conditions that developed in response to a particular perturbation. The reference reach approach is most appropriate in the following settings: relatively undeveloped watersheds, watersheds which have been fully developed for many decades, and where causes of channel disruption are easily identified and are limited to local causative agents, such as local landslide, local grazing impacts, or any innumerable human channel disturbances. Reference reach approached are usually not appropriate in watersheds with actively changing hydrologic or sediment supply conditions, channel systems which have not fully responded to changes in watershed conditions; and where causative agents are on a watershed scale, rather than a local or reach scale.

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A reference reach should be selected from the same watershed and be of similar channel slope, geology, soils, and vegetation as the design channel. The reference reach should be long enough to derive meaningful mean conditions, and acceptable limits for various attributes and characteristics. For design of individual channel characteristics, information and data from a number of reference reaches is desirable.

Defining realistic goals and objectives is critical to this approach to restoration. Short-term conditions may be predictable, however, the future condition of the replicated reach is difficult to predict. If the replicate is accurate, the long-term outcome should reflect natural process influenced conditions.